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The Cost of Breast Cancer Screening in the Medicare Population

Cary P. Gross, MD^{1,2}, Jessica B. Long, MPH^{1,2}, Joseph S. Ross, MD, MHS^{1,2}, Maysa M. Abu-Khalaf, MD³, Rong Wang, PhD^{1,4}, Brigid K. Killelea, MD, MPH^{1,5}, Heather T. Gold, PhD⁶, Anees B. Chagpar, MD, MA, MPH, MSc^{1,5}, and Xiaomei Ma, PhD^{1,4}

¹Cancer Outcomes, Public Policy and Effectiveness Research (COPPER) Center, Yale Cancer Center and Yale University School of Medicine

²Section of General Internal Medicine, Department of Internal Medicine, Yale University School of Medicine

³Section of Medical Oncology, Department of Internal Medicine, Yale University School of Medicine

⁴Department of Epidemiology and Public Health, Yale University School of Medicine

⁵Department of Surgery, Yale University School of Medicine

⁶Departments of Population Health and Medicine, New York University School of Medicine and New York University Cancer Institute

Abstract

Background—Little is known about the cost to Medicare of breast cancer screening or whether regional-level screening expenditures are associated with cancer stage at diagnosis or treatment costs, particularly as newer breast cancer screening technologies like digital mammography and computer aided detection (CAD) have diffused into the care of older women.

Methods—Using the linked Surveillance, Epidemiology and End Results-Medicare database, we identified 137,274 women aged 66–100 who had not had breast cancer, and assessed the cost to fee-for-service Medicare of breast cancer screening and work-up during 2006–07. For women who developed cancer, we calculated initial treatment cost. We then assessed screening-related cost at the Hospital Referral Region level, and evaluated the association between regional expenditures and work-up test utilization, cancer incidence, and treatment costs.

Results—In the United States, the annual costs to fee-for-service Medicare for breast cancer screening-related (comprised of screening plus work-up) and treatment were \$1.08 billion, and \$1.36 billion, respectively. For women age 75 years and over, annual screening-related expenditures exceeded \$410 million. Age-standardized screening-related cost per beneficiary varied more than two-fold across regions (from \$42 to \$107 per beneficiary); digital screening

Corresponding author: Cary P. Gross, MD, Yale University School of Medicine, Primary Care Center, 333 Cedar Street; PO Box 208025, New Haven, CT 06520, phone: 203-688-8588, fax: 203-688-4092, cary.gross@yale.edu.

Requests for reprints: Cary P. Gross, MD, PO BOX 208025, New Haven, CT 06520-8025

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Conflicts of interest: Drs. Ross and Gross are members of a scientific advisory board for FAIR Health, Inc. Dr. Abu-Khalaf has received research funding and has served as a consultant for Abraxis Oncology (currently Celgene), Merck, Novartis, Glaxo-Smith-Kline, and Genentech/Roche.

Author contributions: Drs. Gross, Ross, Chagpar, Abu-Khalaf, Killelea, Ma, and Ms. Long were responsible for the conception and design of this work. Dr. Gross and Ms. Long drafted the manuscript. Ms. Long conducted the statistical analysis. Dr. Gross was responsible for acquisition of data and obtained funding. Drs. Gross and Ma provided supervision. All authors participated in the analysis and interpretation of the data and critically revised the manuscript for important intellectual content.

mammography and CAD accounted for 65% of the difference in screening-related cost between HRRs in the highest and lowest quartile of cost. Women residing in high-screening-cost HRRs were more likely to be diagnosed with early stage cancer (incidence rate ratio, 1.78; 95% CI, 1.40–2.26). There was no significant difference in the cost of initial cancer treatment per beneficiary between highest and lowest screening-cost HRRs (\$151 v 115, $p=.20$).

Conclusions—The cost to Medicare of breast cancer screening exceeds \$1 billion annually in the fee-for-service program. Regional variation is substantial and driven by the use of newer and more expensive technologies; it is unclear whether higher screening expenditures are achieving better breast cancer outcomes.

Background

As the spectrum of cancer care includes screening as well as treatment, a comprehensive understanding of breast cancer cost must incorporate cost of screening and associated work-up. While the body of evidence concerning Medicare expenditures for cancer treatment has grown, relatively little is known about cost associated with screening Medicare beneficiaries for breast cancer.^{1–3} This is especially important among older women, as recent guidelines have concluded that there is insufficient evidence to assess the benefits and harms of screening mammography in women 75 years or older.^{4,5}

It is particularly timely to consider the cost implications of breast cancer screening, as newer breast cancer screening technologies such as digital mammography and computer aided detection (CAD) have expanded the options available to clinicians and are diffusing into clinical practice.^{6,7} The adoption of these new technologies can increase costs directly, through reimbursement for the tests, and also lead to higher rates of supplementary imaging, biopsy, or cancer detection.^{8,9} It is critical to assess the relation between screening expenditures and population outcomes, since newer modalities can increase cancer detection rates, but may not improve patient outcomes, particularly among older women.^{10–14}

Ideally, higher breast cancer screening expenditures at the population level should correspond to earlier stage at diagnosis, lower treatment cost, or both. This can be evaluated by comparing differences in screening cost and cancer outcomes across geographic regions, hypothesizing that women living in regions that “invest” more in screening services may be less likely to be diagnosed at a later stage. However, in actual practice, it is unclear whether higher screening costs are associated with earlier stage at diagnosis or lower cancer treatment costs at the population level.

To address these knowledge gaps, we estimated national breast cancer screening and treatment costs in the Medicare fee for service program. Our second objective was to assess regional variation in breast cancer screening cost, while our third objective was to determine the association between regional screening cost and breast cancer incidence and treatment costs. These data will inform clinicians and policy makers, in a context of debate about Medicare reimbursement for various cancer screening modalities and concerns about growth in cancer expenditures.

Methods

Study Overview

We conducted a retrospective cohort study of female Medicare beneficiaries who were free of breast cancer as of December 31, 2005 and followed them for two years to assess breast cancer screening, work-up of suspicious lesions, and incident breast cancer. For the subgroup of women who developed breast cancer during the study period, we estimated treatment cost during the initial 12 months after diagnosis.³ At the regional level, we then

evaluated the association between screening cost and outcomes (overall and stage-specific breast cancer incidence and treatment cost). The Yale Human Investigation Committee determined that this study did not directly involve human subjects.

Data Source and Study Sample

We used the Surveillance, Epidemiology, and End Results (SEER)-Medicare database, which links patient-level information on all incident cancer patients reported to SEER registries with Medicare claims and also maintains a file of 5% sample of Medicare beneficiaries without cancer who live in SEER registries.¹⁵ The population-based SEER registries account for approximately 28% of the U.S. population.¹⁶ To create a cohort eligible for breast cancer screening in whom we could measure cancer incidence, we selected female beneficiaries from Medicare's 5% sample (cancer and non-cancer) who lived in a SEER region during 2006–7 and had not had breast cancer as of December 31, 2005 documented through either SEER or Medicare ICD-9 billing codes. To be included, a woman had to be 66–100 years old on January 1, 2006, have a valid zip code, and have continuous fee-for-service Medicare Part A and B coverage throughout the study period. Among women who developed breast cancer in 2006–2007, we excluded those women whose cancer was reported only on death certificate or autopsy or had missing diagnosis date.

We categorized race as white, black, other and median household income at zip code level according to quintiles. We used a modified list of Elixhauser comorbidity conditions to assess comorbidity (Appendix Table 1).^{17–19}

Screening and work-up cost

We assessed the use and cost of breast cancer screening-related (comprised of screening plus work-up) procedures using ICD-9 procedure and diagnosis codes and Healthcare Common Procedure Coding System codes (HCPCS; Appendix Table 2).^{20–25} Screening includes screening mammography (digital and film) and CAD billed with screening mammography, while work-up includes diagnostic mammography (digital and film), CAD billed with diagnostic mammography, other breast imaging and biopsy. We used a validated algorithm with updated procedure codes to identify whether a mammography was screening or diagnostic.²⁶ We calculated the cost of these procedures according to the actual reimbursement by Medicare.^{27–30} Costs were adjusted to 2009 USD accounting for temporal and geographic variation.^{30,31}

Treatment cost

To assess cancer treatment costs, we used a matched control group approach to determine the difference in Medicare expenditures between women diagnosed with breast cancer and women without a cancer diagnosis. This enabled us to account for “background” medical expenditures, with the difference in costs between the cancer and non-cancer groups attributable to cancer-related costs. Women diagnosed with their first breast cancer in 2006 or 2007 were matched 1:1 with women from Medicare's 5% sample who never had breast cancer based on SEER region, age quartile, comorbidity (0 vs. 1+ condition), and regional quartile Medicare expenditures in the 12 months before diagnosis. After assigning a matched pair, Medicare payments from the month of diagnosis through 12 months later were summed for both cases and controls.^{3,30} We subtracted Medicare payments for the control and for screening during the month of diagnosis from the total payments for the case and refer to the difference as treatment cost^{3,30}. To test the stability of treatment cost in the 5% sample, we calculated treatment cost as described above for all women reported to SEER as having been diagnosed with their first breast cancer in 2006 or 2007; the difference in national treatment cost estimates was <2%.

Extrapolating to national cost

Using Medicare enrollment tables for the study period, we calculated the number of female fee-for-service Medicare beneficiaries age 65–74, 75–84 and 85 or older.³² For each age group, we multiplied the number of beneficiaries by our calculated screening cost per beneficiary and summed to estimate total Medicare breast cancer screening cost. Similarly, we applied age-specific SEER cancer incidence to the number of beneficiaries and multiplied by treatment cost per diagnosed beneficiary to estimate total Medicare expenditures for the first year of breast cancer treatment.³³

Regional Variation

We used Hospital Referral Regions (HRRs) to examine geographic variation.³⁴ We assigned women to HRR based on zip code of residence, and *a priori* restricted the sample to HRRs with 50 or more women who were diagnosed with breast cancer in the full SEER-Medicare data.³⁵ The age-standardized cost estimates for each HRR were generated by applying age-specific costs in each HRR to the national age distribution (described above) of female fee-for-service Medicare beneficiaries.

Statistical Analysis

We assigned women to the quartile of her HRR screening-related cost and assessed use of screening and work-up procedures according to screening-related cost using Cochran-Armitage test of trend, as well as chi-square tests. We then used Poisson regression to assess the relation between quartile of screening-related cost and breast cancer incidence rate, adjusting for age, race, comorbidity and income. Women contributed person-time from January 1, 2006 until the earliest of breast cancer diagnosis, death, or December 31, 2007. At the HRR level, we used linear regression to determine whether higher quartile of screening-related cost was associated with increased treatment cost adjusting for mean age, income and percent white at HRR level, as well as average annual Medicare expenditures for all care per capita within that HRR. We used SAS version 9.2 (SAS Institute, Inc., Cary, NC) to conduct all analyses.

Results

There were 137,274 women in the study cohort; 41.8% were less than 75 years of age, 83.8% were white and half had one or more comorbid conditions (Table 1). During the study period, 43.5% of women had at least one screening mammogram with women 66–74 years being much more likely than women 85–100 years to receive a mammogram (57.2% v 15.2% respectively, $p < .001$). A higher percentage of women with highest quintile of median household income received a screening mammogram, while a lower percentage of those with increased number of comorbid conditions had screening mammogram ($p < .001$ for both). During that time, the average annual breast screening-related cost per beneficiary was \$63. There was a strong inverse relation between age and cost, with breast cancer screening-related costs decreasing from \$84 per beneficiary age 66–74 years to \$60 (age 75–84 years) and \$21 for women 85–100 years of age ($p < .001$, Table 2). During the same time period, the mean cost of initial treatment per diagnosed patient was approximately \$16,600 for all ages and \$21,300, \$12,800, and \$11,500 for women diagnosed at ages 66–74, 75–84, and 85–100, respectively ($p < .001$).

Extrapolating these costs to the US fee-for-service Medicare population, the annual costs to Medicare for breast cancer screening and workup of suspicious lesions were \$723.1 million and \$359.0 million, respectively, with a screening-related total of \$1.08 billion. This compares with an annual cost to Medicare of \$1.36 billion for treatment. In the subgroup of

women who were older than 75 years, total screening-related and treatment costs were \$410.6 million and \$498.5 million, respectively.

Regional Variation

There was substantial regional variation in screening-related cost per beneficiary among the 75 HRRs in this analysis (Figure 1). At the HRR level, the mean screening-related cost per beneficiary ranged from approximately \$40 to \$110, with a median of \$64 (interquartile range [IQR], \$57, 72). Similarly, there was nearly a two-fold difference in cost per screened beneficiary between the highest and lowest HRRs, with a median HRR-level cost of \$129 (IQR, \$120–143).

At the regional level, the use of specific screening tests was correlated with regional-level screening-related cost. The use of screening mammography increased from 40.9% of women in the lowest quartile of HRR screening-related expenditures, to 47.6% in the highest quartile ($p < .001$; Figure 2A). Although there was no significant relation between quartile of regional screening-related costs and the use of film screening mammography (p -value for trend: .92), women living in higher-cost regions were significantly more likely to undergo digital screening mammography. Approximately 10% of women who lived in the lowest quartile region received at least one digital screening mammogram, increasing to 13.9%, 16.9%, and 20.2% in the second, third, and fourth quartile of screening-related costs, respectively ($p < .001$). There was a two-fold difference in the screening CAD use between women in the highest and lowest quartiles of HRR screening-related cost, 38.6% vs. 19.6%, respectively ($p < .001$).

Patients in HRRs with the highest screening-related cost also tended to have higher utilization of work-up procedures such as diagnostic mammography, other breast imaging or biopsy when compared with lower cost regions (Figures 2B). For instance, while 2.1% of all women who lived in the highest quartile HRRs underwent biopsy, 1.4% of women in the lowest cost regions underwent biopsies during the study period ($p < .001$).

Digital screening mammography accounted for 47% of the difference in costs between women living in HRRs with the highest and lowest quartiles of screening related cost. Breast biopsy (21%) and CAD (18%) were also major contributors to regional cost difference, while utilization of film screening mammography (5%), diagnostic mammography (7%), or other imaging modalities (2%) did not contribute substantively.

Cancer Incidence and Treatment Cost

Women residing in areas with higher screening-related cost per beneficiary were significantly more likely to be diagnosed with breast cancer (adjusted Incidence Rate Ratio (IRR), 1.54 for highest vs. lowest quartile; 95% CI, 1.29–1.84; Table 3). The increase in breast cancer diagnoses was attributable to early stage cancers, as women residing in HRRs with higher screening-related cost tended to have a significantly higher incidence rate of in situ or stage I cancers. When we assessed in situ and stage I cancer incidence separately, those in the second, third and fourth quartiles had, significantly increased risk of being diagnosed with stage I breast cancer compared to those in the first quartile: 40%, 49% and 65%, respectively. A similar trend was found for incidence of in situ disease, but only those in the fourth quartile of screening cost had significantly higher incidence of in situ disease than those in the first quartile (IRR, 2.12; 95% CI, 1.36–3.30). There was no significant association between quartile of screening-related cost and the incidence of stage IV breast cancer. The incidence of stage IV cancer was 0.19 and 0.18 per 1,000 in the highest and lowest quartiles, respectively. The results were similar when we defined HRRs by quartile of screening-related cost per screened beneficiary.

There was no significant relation between screening and treatment costs at the regional level. Even after adjustment for mean age, income, percent white within HRR and average annual total Medicare expenditures per capita, the difference in cost between highest and lowest quartile of screening-related cost per beneficiary was not significant (\$115 v \$151, $p=.20$). Findings were similar when HRRs were classified according to screening-related cost per screened beneficiary.

Conclusions

We found that the Medicare fee-for-service program is spending over \$1 billion per year on breast cancer screening and work-up of suspicious lesions. This accounted for over 45% of the \$2.42 billion total spent by Medicare on screening and the initial treatment phase of breast cancer, suggesting that analyses which focus exclusively on treatment have overlooked a significant contributor to cancer costs. Moreover, over \$410.6 million annually is being spent on screening and work-up of women age 75 years and older, although there is insufficient evidence to assess the benefits and harms of screening mammography in this age group.⁵ This reinforces the need to develop evidence to guide both clinical decision making and coverage decisions.

There was substantial variation in screening-related cost across regions, which was largely attributable to digital screening mammography and CAD, rather than to differential use of screening mammography. Although breast biopsy was rarely performed, the 50% relative difference in biopsy rates across regions was notable and may represent work-up effect of CAD or digital mammography in high cost regions. Data suggests these modalities can increase recall rate, including digital biopsy, but results have been mixed.^{36–38}

Women residing in high screening-cost regions were as much as 78% more likely to be diagnosed with early stage or in situ breast cancer as women in lower cost regions. The difference in crude incidence of overall and early stage cancers between high and low cost areas was approximately 1 per 1,000 women, which was statistically significant. Notably, the difference in the incidence of diagnosed stage IV cancer was not significant, and the absolute difference between highest and lowest cost areas was approximately 1 in 100,000 women. Taken together, these findings suggest overdiagnosis of breast cancer in the higher cost regions. This is consistent with recent findings from the Norwegian Screening Trial, which found that women residing in areas that implemented a mammography screening program were significantly more likely to be diagnosed with breast cancer, and that 15–25% of cases were overdiagnosed.³⁹

Although our study did not set out to assess the effectiveness of CAD or digital mammography, our findings suggest limited effectiveness of these modalities in older average-risk women. For example, the Digital Mammographic Imaging Screening Trial (DMIST) found that digital mammography does not perform better than film mammography in women 65 years or older.⁴⁰ As the field of radiology moves towards digital technology, it is important to note that digital will frequently be the only option available. Our results suggest that the cost and effectiveness of such evolutions of technology should be promptly and rigorously evaluated; higher costs associated with adoption of newer modalities may not necessarily yield superior outcomes.

We found that higher screening-related cost did not translate into lower treatment cost at the population level. There was a non-significant trend towards the higher screening-related cost areas having higher treatment costs, which may be associated with the higher rate of diagnosing early stage cancer in the higher screening expenditure areas. Because cancer diagnosis was a rare event, there were not enough incident cancer patients to affect treatment

costs at the population level. Additionally, the costs associated with higher detection rates for early stage cancer could have been partially balanced out by the slightly (and non-significantly) lower rates of metastatic cancer detected in the higher cost regions.

There are several important considerations. We only have two years of follow-up to measure cancer incidence, which may not be long is not long enough assess advanced stage incident cancer or determine causality between increased spending and breast cancer incidence. Future work should explore this relation over a longer follow-up period, including longer assessment of cost and outcomes. It is also important to note that this study relied on administrative claims and may not capture all procedures performed, but our results are similar to a prior large registry study.⁴¹ The SEER-Medicare database relies on physician report and an algorithm to identify hispanic ethnicity of subjects which has been questioned, so we chose to categorize race as white, black, other without respect to ethnicity.⁴² Our estimates of cancer incidence (4.40 per 1,000 person-years) were slightly lower than those in the overall SEER program (4.82 per 1,000 person-years), but this is primarily due to SEER's inclusion of first and subsequent breast cancers, while our study sample was restricted to women with first breast cancer only.⁴³

In summary, the costs of breast cancer care in the Medicare population, when incorporating screening costs, are substantially higher than previously documented and the adoption of newer screening modalities will likely contribute to further growth. The growth trajectory may be steeper than projected due to Medicare's reimbursement strategy which supports rapid adoption of newer modalities, frequently without adequate data to support their use.¹

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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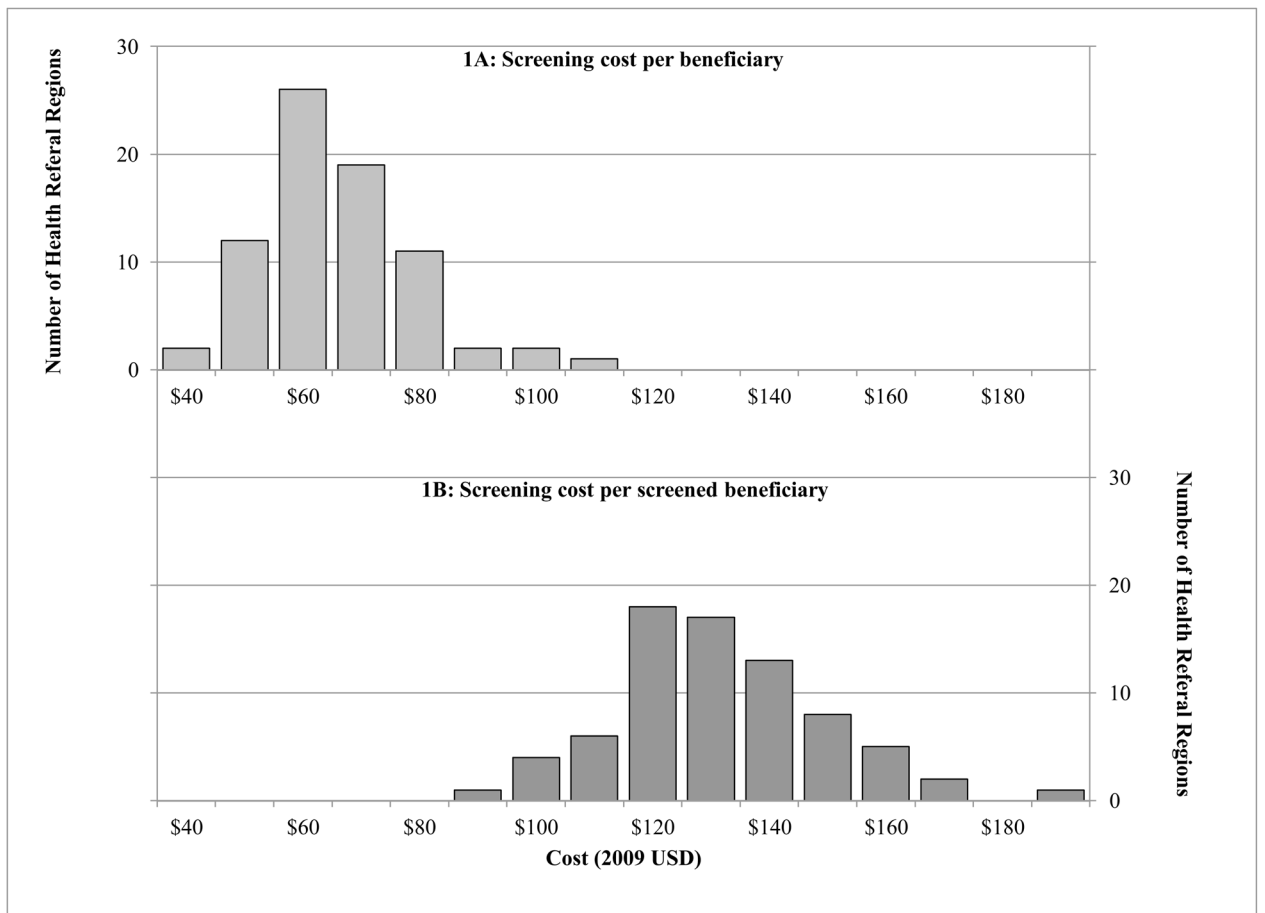
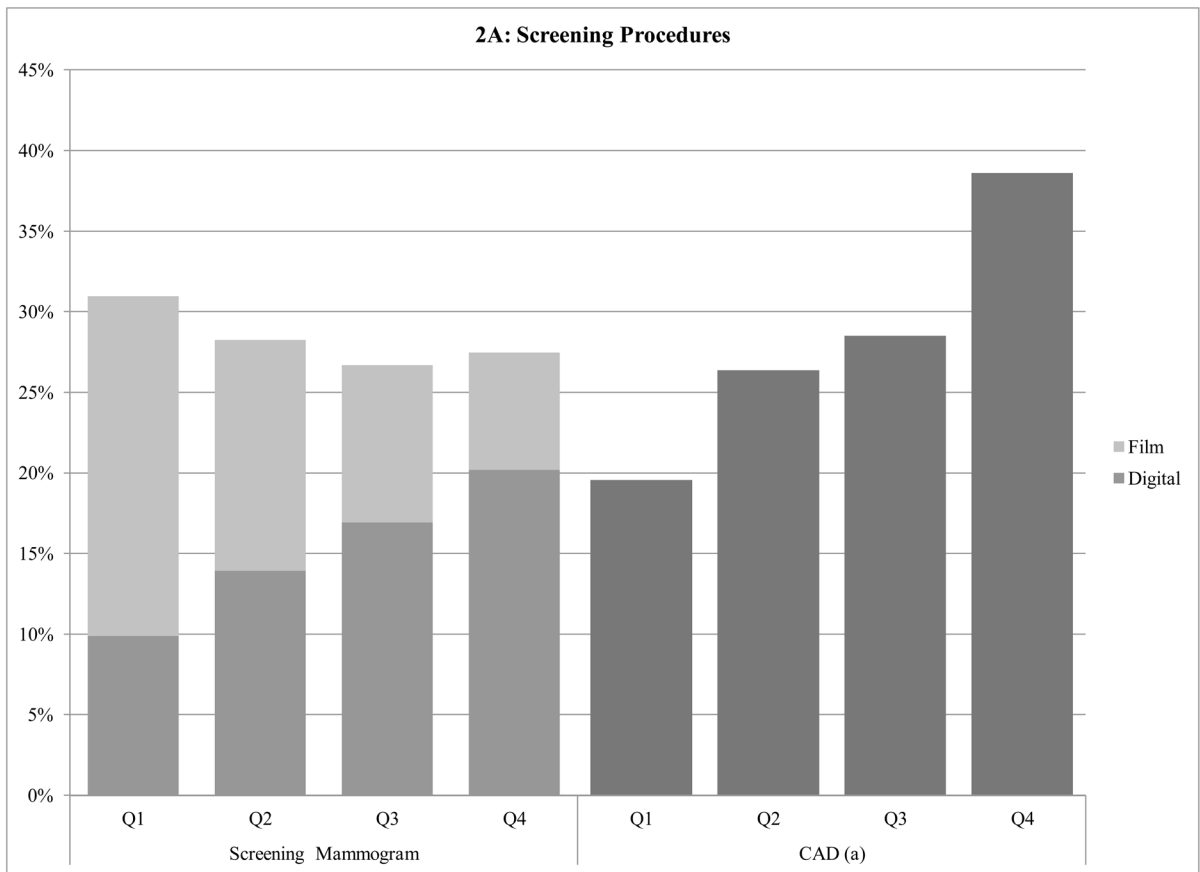


Figure 1.
Regional variation in breast cancer screening costs



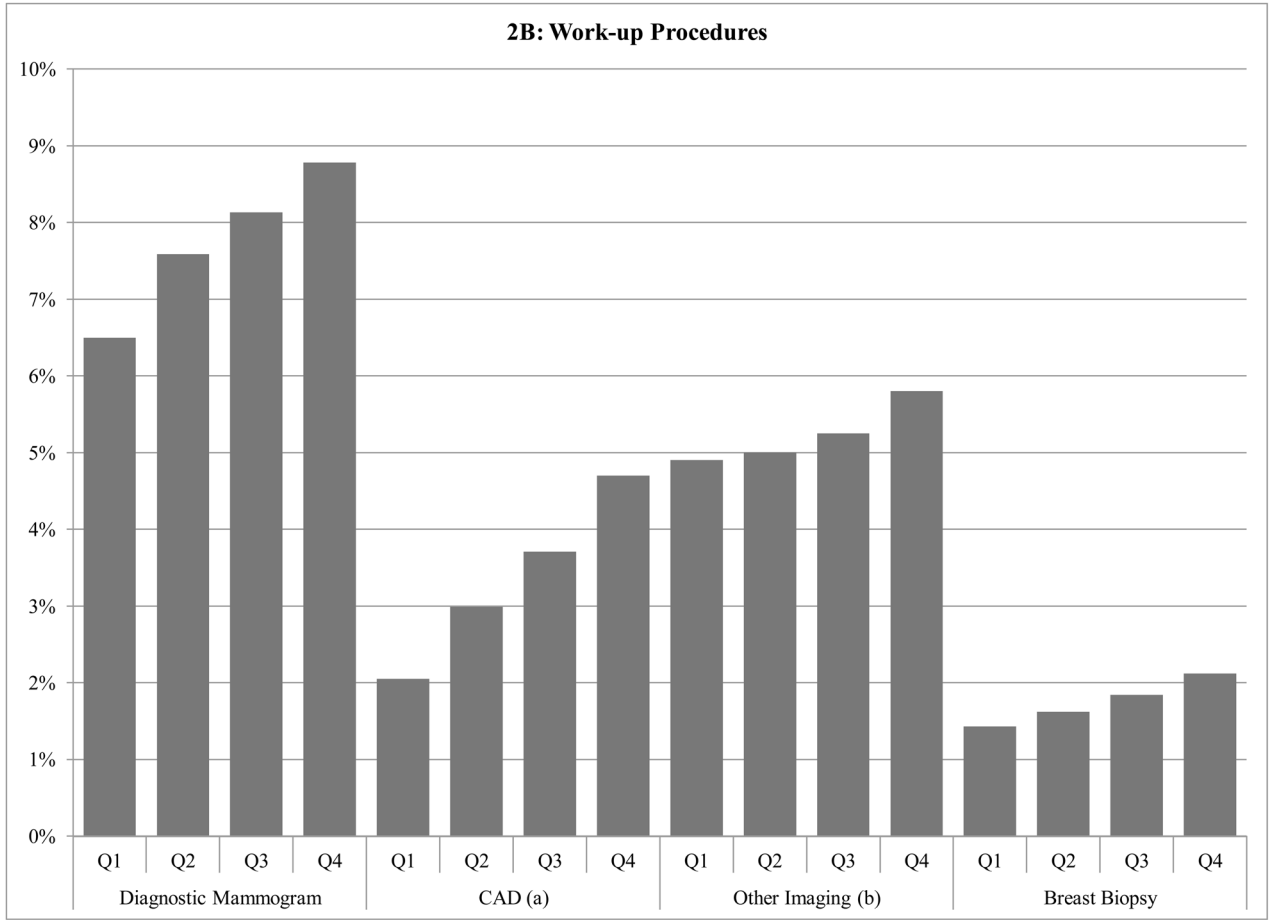


Figure 2.

Figure 2A: Screening mammography and Computer Aided Detection use according to Health Referral Region screening-related cost

Figure 2B: Work-up breast imaging and biopsy use according to Health Referral Region screening-related cost

^a CAD=Computer Aided Detection

^b Other Imaging Includes: Breast Ultrasound, Breast MRI, positron emitting tomography imaging; computed tomography of head, brain, thorax, abdomen; MRI of brain, brainstem; radiologic examination, consultation, report; three-dimensional rendering; bone and joint imaging; radiopharmaceutical localization of tumor

^c 1st quartile screening + work-up cost per beneficiary: <\$57, 2nd quartile: \$57–64, 3rd quartile: \$65–70, 4th quartile: >\$70

Table 1

Demographic Characteristics of Study Sample

| Total Sample | N | % | % Patients Receiving Screening Mammography |
|--------------------------------|----------------|----------|---|
| | 137,274 | | |
| Age | | | |
| 66–74 | 57,417 | 41.8 | 57.2 |
| 75–84 | 55,176 | 40.2 | 42.0 |
| 85–100 | 24,681 | 18.0 | 15.2 |
| Race | | | |
| White | 114,989 | 83.8 | 44.7 |
| Black | 9,952 | 7.3 | 38.8 |
| Other | 12,333 | 9.0 | 36.4 |
| Median Household Income | | | |
| < \$33,000 | 26,036 | 19.0 | 38.7 |
| \$33,000–\$39,999 | 22,325 | 16.3 | 43.2 |
| \$40,000–\$49,999 | 29,312 | 21.4 | 43.8 |
| \$50,000–\$62,999 | 27,348 | 19.9 | 44.9 |
| \$63,000 | 28,157 | 20.5 | 47.2 |
| unknown | 4,096 | 3.0 | 40.2 |
| Comorbid Conditions | | | |
| 0 | 68,727 | 50.1 | 47.4 |
| 1 to 2 | 49,132 | 35.8 | 44.8 |
| 3+ | 19,415 | 14.1 | 26.6 |

^aChi-square p-value for receipt of screening mammography and demographic characteristics <.001 for all comparisons in table.

Table 2
Average Annual Cost to Medicare for Breast Screening and Treatment (\$2009 USD) during 2006–7

| | Age Group (number beneficiaries ^d) | | | | All Ages |
|--|--|-----------------|------------------|-----------|-----------|
| | 66–74 8.04 M | 75–84 5.84 M | 85–100 2.87 M | | |
| Screening Cost ^b | Cost Per Beneficiary | \$56 | \$40 | \$13 | \$ 724 M |
| | Total Cost | \$ 448 M | \$ 236 M | \$ 39.2 M | |
| Work-Up Cost ^c | Cost Per Beneficiary | \$28 | \$20 | \$8 | \$ 359 M |
| | Total Cost | \$ 223 M | \$ 114 M | \$ 22.2 M | |
| Screening-Related = Screening + Work-Up Cost | Cost Per Beneficiary | \$84 | \$60 | \$21 | \$ 1.08 B |
| | Total Cost | \$ 671 M | \$ 350 M | \$ 60 M | |
| Treatment Cost | Number Diagnosed with Breast Cancer | 40,607 | 29,388 | 10,617 | |
| | Total Cost | \$ 864 M | \$ 377 M | \$ 122 M | \$ 1.36 B |

^aNumber of national fee for service Medicare beneficiaries

^bIncludes cost for screening mammography (digital and film) and screening computer aided detection.

^cIncludes cost for diagnostic mammography (digital and film), diagnostic computer aided detection, breast and related imaging and biopsy.

Table 3
The association of regional screening-related cost and breast cancer incidence and treatment cost

| | Quartile | Overall Incidence | | In Situ or Stage I Incidence | | Stage IV Incidence | | Treatment Cost ^e (per beneficiary) | |
|---|----------|-------------------------------|---------------------------|------------------------------|------------------|--------------------|------------------|---|---------|
| | | Annual Incidence ^c | IRR ^d (95% CI) | Annual Incidence | IRR (95% CI) | Annual Incidence | IRR (95% CI) | Cost | P-value |
| Screening + Work-Up Cost ^a (per beneficiary) | 1 | 3.3 | REF | 1.8 | REF | 0.2 | REF | \$115 | REF |
| | 2 | 4.7 | 1.34 (1.13–1.60) | 2.5 | 1.41 (1.11–1.80) | 0.2 | 0.87 (0.45–1.71) | \$157 | .37 |
| | 3 | 5.0 | 1.40 (1.17–1.68) | 2.7 | 1.48 (1.16–1.90) | 0.3 | 1.11 (0.57–2.17) | \$136 | .50 |
| | 4 | 4.6 | 1.54 (1.29–1.84) | 2.8 | 1.78 (1.40–2.26) | 0.2 | 0.84 (0.40–1.75) | \$151 | .20 |
| Screening + Work-Up Cost ^b (per screened beneficiary) | 1 | 3.6 | REF | 1.8 | REF | 0.2 | REF | \$148 | REF |
| | 2 | 4.1 | 1.12 (0.94–1.34) | 2.3 | 1.35 (1.06–1.71) | 0.3 | 0.68 (0.34–1.36) | \$138 | .96 |
| | 3 | 5.1 | 1.29 (1.09–1.52) | 2.8 | 1.44 (1.14–1.82) | 0.3 | (00.98.53–1.83) | \$116 | .55 |
| | 4 | 4.8 | 1.35 (1.14–1.60) | 2.9 | 1.66 (1.32–2.09) | 0.2 | 0.70 (0.35–1.43) | \$161 | .73 |

^a 1st quartile screening + work-up cost per beneficiary: <\$57, 2nd quartile: \$57–64, 3rd quartile: \$65–70, 4th quartile: >\$70

^b 1st quartile screening + work-up cost per screened beneficiary: <\$121, 2nd quartile \$121–131, 3rd quartile: \$131–143, 4th quartile: > \$143

^c Annual Incidence per 1,000 person-years

^d Incidence Rate Ratio (IRR) adjusted for age, race, comorbidity, and income

^e Treatment cost p-value adjusted for mean age, income, percent white, and average annual total Medicare expenditures per capita of health referral region.